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IMPACT OF OZONE EXPOSURE ON VEGETATION IN ONTARIO

R. G. Pearson and J. A. Donnan, Air Resources Branch, Ontario Ministry of the Environment, 880 Bay Street, Toronto, Ontario M5S1Z8 and Policy and Planning Branch, Ontario Ministry of the Environment, 135 St. Clair Avenue West, Toronto M4V 1P5.

This report summarizes the results of extensive efforts which have been undertaken in Ontario to assess the impact of ozone and other oxidants on all types of terrestrial vegetation and to provide a scientific basis for the derivation of economic benefits which would result from an ozone control program (Pearson, 1989 and Donnan, 1989). Other objectives were to assess the response of vegetation to other regional pollutants, to multiple pollutant exposures and to determine the ozone exposure threshold which would be required to virtually eliminate adverse impacts on crops, ornamentals and forests in the province.

In the case of agricultural crops, the derivation of production losses was accomplished by a thorough review of the scientific literature as well as many un-published government and university reports and conference proceedings and the development of a database for crop response to seasonal mean ozone concentrations of 40 and 50 ppb. A total of 19 crops were assessed in this manner, and for 12 of the 19, a comprehensive adjustment factor approach was utilized in the estimation of crop loss in Ontario due to ozone to compensate for geographic, agronomic and experimental variability in the research results. Based on these findings (Table 1) and an analysis of the Ontario ozone database (Table 2) in which minimum, maximum and average contours of seven-hour seasonal means were contoured via a kriging technique (Figure 1 - average), it was subsequently determined by Donnan (1989) that the annual value of increased crop production in Ontario would average $39 million, ranging from $14 to $61 million per year (Table 3). These estimates, which are expressed in 1986-87 dollars, assume that no added costs of cultivation or harvesting would be incurred. A statistical analysis of the Ontario ozone database from a seasonal average and hourly basis revealed that attainment of the existing one hour ambient air criterion of 80 ppb (Figure 2) would result in seasonal mean ozone levels below 40 ppb, thereby virtually eliminating productivity type impacts on seasonally exposed ozone sensitive vegetation in the province.

In the case of ornamentals, including landscape trees, turfgrass and Christmas trees, productivity losses were estimated at an average of 5% with a range of 2-7% in the southern portion of the province exposed to seasonal mean ozone concentrations at or above 40 (Figure 1). The value of the potential increased revenues to ornamental plant growers, if ozone levels were reduced to below 40 ppb (seasonal mean averages), has been estimated by Donnan (1989) to range between $2 and $8 million per year (Table 3)

Although foliar injuries have been documented on many forest species in Ontario, the state of knowledge at this time was insufficient to develop a reliable estimate of productivity losses. However, it has been noted (Pearson, 1989) that in Ontario, the major portion of the forest industry is located in an area of the province where ozone levels normally are lower than in the agricultural production areas of southern and central Ontario.

An evaluation of the impacts of other oxidants, including peroxyacetyl nitrate (PAN) and nitrogen dioxide failed to indicate any concern for direct impacts on vegetation at existing air quality levels. However, interactions involving these oxidants with ozone can not be ruled out due to a dearth of research conducted under growing season, field conditions. In the case of multiple exposures involving ozone and sulphur dioxide or acid rain/fog, there has been field type research that appears to rule out any significant enhancement of crop productivity losses. In the case of trees, the role of pollutant interactions which have been documented under controlled experimental conditions has not been clarified under natural or stand conditions.

In summation, this investigation documented productivity losses to crops and ornamental growers due to prevailing ozone concentrations. If ozone levels were reduced to a seasonal mean below 40 ppb, the value of the extra crop production and revenues to ornamental plant growers could range from $17 to $70 million, depending on the seasonal precursor emissions and the regional weather patterns for southern Ontario. These estimates can be compared to estimates of the costs of reducing ozone precursor pollutants from stationary and mobile sources in Ontario which are being prepared as part of an oxidant strategy for the province.

References

Donnan, J. A. (1989). Potential benefits of oxidant control in Ontario. (draft). Policy and Planning Branch, Ontario Ministry of the Environment. pp. 51

Pearson, R. G. (1989). Impact of ozone exposure on vegetation in Ontario. (draft). Air Resources Branch, Ontario Ministry of the Environment.

Figure 2

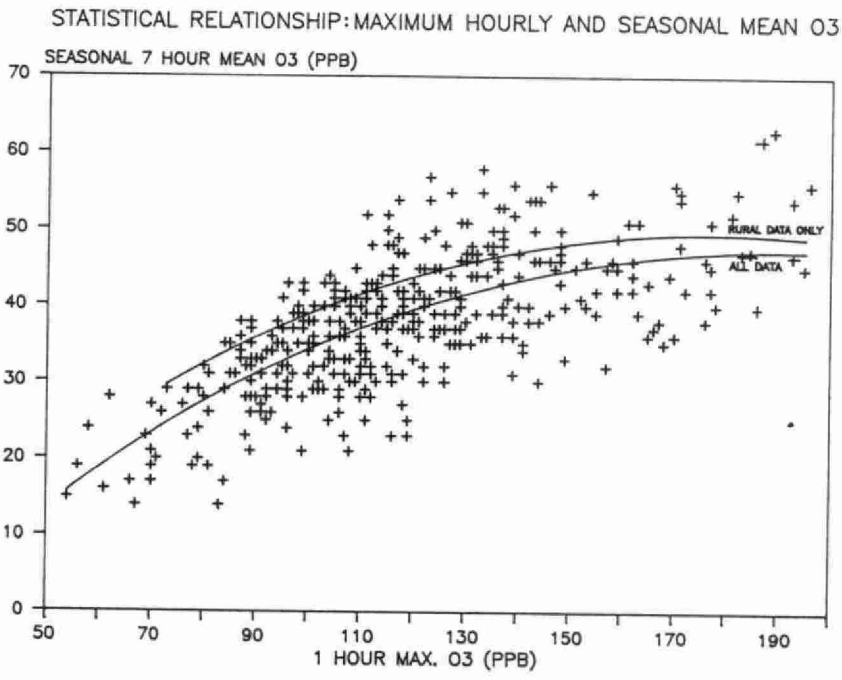

FIGURE 1 CONTOURS OF AVERAGE SEASONAL 7 HOUR MEAN OZONE CONCENTRATIONS IN ONTARIO : 1974-88

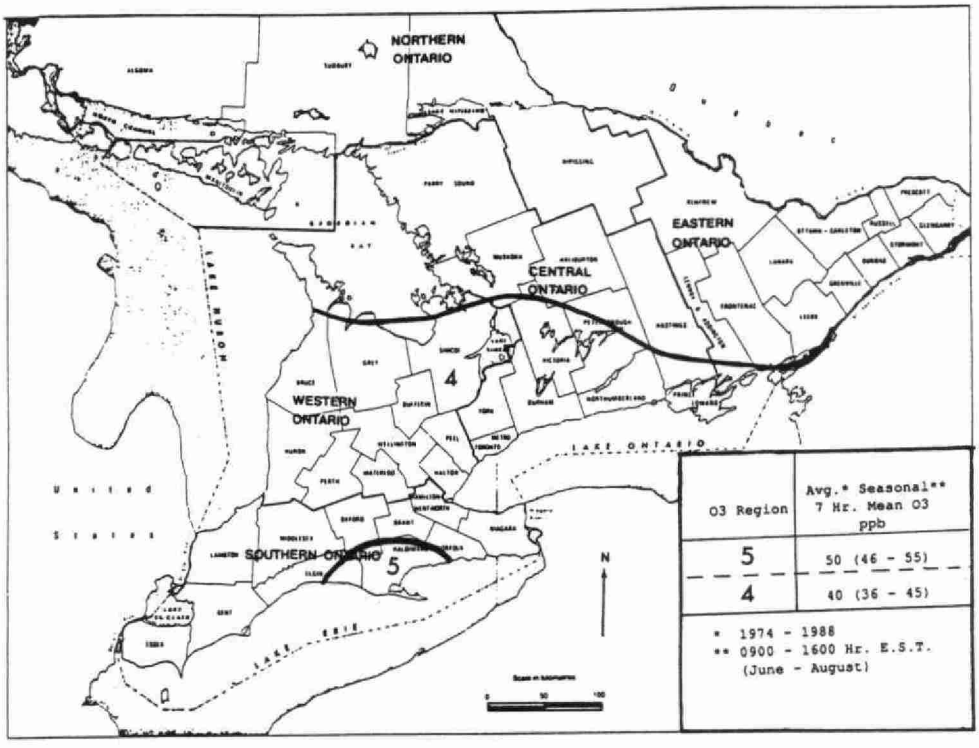

Table 1

SUMMARY OF ESTIMATED CROP LOSS DUE TO OZONE EXPOSURE IN ONTARIO

CROP	AVERAGE YIELD LOSS IN ONTARIO - OZONE REGION 4	OZONE REGION 5
AT RISK		
Dry Beans	10.6	10.7
Potato	5.6	6.9
Onion	5.6	9.2
Hay	4.4	4.3
Turnip/Rutabagas	3.8	7.4
Winter Wheat	3.4	5.5
Soybean	3.2	6.2
Spinach	2.5	4.7
Green/Snap Bean	2.2	4.4
Flue-cured Tobac	2.1	3.9
Tomato	1.6	5.4
Sweet Corn	1.4	2.3
MARGINALLY AT RISK		
Cucumber	1	2
Squash	1	2
Pumpkin	1	2
Melon	1	2
Grapes	1	2
Burley Tobacco	1	2
Beet	1	2

Table 2

SUMMARY OF OZONE CONCENTRATIONS (ppb) AT SELECTED RURAL AND URBAN LOCATIONS IN SOUTHERN ONTARIO: 1988 VS 1974-88

LOCATION	NO. YRS. MONITORED (1974-88)	URBAN/ RURAL	MAX.* 1 HR O3 AVG.*** (RANGE) 1988	1974-88	7 HR SEASONAL MEAN** O3 AVG.*** (RANGE) 1988	1974-88	NO HOURS**** O3 > 80 ppb AVG.*** (RANGE) 1988	1974-88	100 ppb AVG.*** (RANGE) 1988	1974-88	120 ppb AVG.*** (RANGE) 1988	1974-88
WINDSOR	15	U	188	148 (104 - 274)	62	45 (34 - 62)	173	61 (12 - 173)	68	18 (1 - 68)	26	5 (0 - 26)
MERLIN	10	R	133	112 (87 - 137)	58	42 (28 - 58)	173	35 (1 - 173)	45	7 (0 - 45)	8	1 (0 - 8)
LONDON	14	U	137	117 (99 - 166)	53	42 (36 - 53)	95	30 (5 - 95)	28	6 (0 - 28)	4	1 (0 - 8)
CENTRALIA	12	R	127	120 (100 - 137)	55	44 (35 - 55)	114	39 (8 - 114)	28	6 (0 - 28)	3	1 (0 - 3)
SIMCOE	14	R	196	129 (99 - 196)	56	51 (43 - 56)	169	54 (20 - 113)	41	12 (0 - 41)	5	2 (0 - 12)
TORONTO a	15	U	159	133 (86 - 201)	42	39 (28 - 60)	71	44 (5 - 162)	20	15 (0 - 98)	5	5 (0 - 49)
STOUFFVILLE	15	R	161	145 (84 - 312)	51	43 (29 - 67)	88	44 (1 - 151)	21	14 (0 - 97)	8	8 (0 - 69)
DORSET	7	R	195	107 (80 - 195)	45	37 (32 - 45)	64	16 (0 - 64)	6	1 (0 - 6)	0	0 (0)
SUDBURY	13	U	84	90 (70 - 118)	36	24 (14 - 36)	0	1 (0 - 3)	0	<1 (0 - 1)	0	0 (0)
OTTAWA	12	U	127	95 (76 - 127)	35	31 (27 - 39)	20	6 (0 - 24)	3	<1 (0 - 3)	0	0 (0)

a SITE AT DOWNTOWN TORONTO LOCATION (BREADLEBANK)

* MAXIMUM 1 HOUR CONCENTRATION (JAN - DEC; 0000-2400 EST)

** JUNE - AUGUST FROM 0900 - 1600 EST (7 HOURS PER DAY)

*** AVERAGE OF ALL YEARS MONITORED

**** DURING PERIOD OF JUNE - AUGUST FROM 0900 - 1600 EST

TABLE 3

VALUE OF PRODUCTION INCREASES FOR AGRICULTURAL AND ORNAMENTAL CROPS FROM OZONE CONTROL

VEGETATION TYPE	POTENTIAL PRODUCTION INCREASE ($ IN MILLIONS) MINIMUM	MEAN	MAXIMUM
AGRICULTURAL CROPS	14.4	38.8	61.4
ORNAMENTALS	2.2	5.7	8.2
TOTAL	16.6	44.5	69.6